UDC 667.622:666.3-121:53.03

PHYSICOCHEMICAL PROPERTIES OF ASPIRATED DUST IN PRODUCTION OF CERAMIC PIGMENTS

V. A. Goremykin,[1] O. A. Frolova,[1] Yu. V. Krasovitzkii,[1] and S. Yu. Panov[1]

Translated from Steklo i Keramika, No. 3, pp. 21 – 23, March, 2001.

The formation conditions and physicomechanical properties of dust emissions formed in the production of ceramic pigments are studied. Practical recommendations are given.

Ceramic pigment production technology involves the processing of dozens of powdered and granulated ingredients, whose processing even using up-to-date machinery is virtually impossible without intense emission of dust into the ambient medium. Therefore, one of the problems that have to be solved in developing adequate sanitary and hygienic working conditions consists in reducing the dust content. The most dust-generating processes are drying, milling, and sifting of components and batch preparation.

The physicochemical properties of dust and the main parameters of dust-gas flows largely determine the reliability and efficiency of dust-collecting systems.

The physicomechanical, electrical, and chemical properties of dust depend on its nature and the technological process which generates it: grinding raw and intermediate materials in various mills, drying and firing in a hot gas flow, etc.

Data of the physicomechanical properties are used in calculation of dust collectors, breechings, hoppers, and dust-collecting equipment and for evaluation of economic effects in utilization of collected dust [1].

The physicomechanical properties of the dust released in production of ceramic pigments are little studied and insufficiently discussed in the technical literature.

The purpose of the present work is the study of aerosols and determination of the main physicomechanical properties of dust. The studies were performed in the ceramic pigment division at the Voronezh Ceramic Works.

Technological emissions differ in the dust content and volume of released air, which depend on the type of machinery, its efficiency, operating conditions, arrangement of technological schemes and aspiration systems, and shelter designs.

The temperature and moisture of the aspirated air emitted by machinery depend on the ambient medium.

The most significant properties of dust are density (true and bulk density) and the degree of dispersion. The true density of dust is the weight of a volume unit of poreless particles, and it is mainly determined by the chemical and mineralogical compositions. The bulk density is the weight of a volume unit of dust and is in direct dependence on the degree of dispersion.

The true density was determined by the pycnometric method based on measuring the volume of liquid displaced by a dust sample (GOST 21119.5–75). The weight of the measured dust volume depends on its bulk density (GOST 21119.6–75).

Later the obtained data on the true density were used to determine the sedimentation diameter of the particles of the particular material, and the bulk density values were used for the design of hopper volumes and selecting dust-discharging devices.

In order to make the optimum selection and representative evaluation of gas-purification systems, one requires data on the dispersion of the dust entering the dust collector, trapped in the collector, and leaving it. The data discriminate with respect to primary dust particle size, the size of conglomerates arising after the coagulation of primary particles in the dust-gas flow, and the size of large flakes and lumps consisting of these particles after they separate from the dust-gas flow.

Based on the dispersion analysis results, one can construct the integral function of the size distribution of particles in the probabilistic-logarithmic coordinate system, and if the resulting plot has the form of a straight line indicating a logarithmically normal distribution, this distribution can be expressed in the form of two parameters: d_m and $\log \sigma$.

The most convenient methods for studying the degree of dispersion of dust include sieve analysis, air separation, liquid sedimentation, cascade impactors, and microscopy. Sieve analysis, air separation, and liquid sedimentation make

[1] Voronezh Ceramic Works, Voronezh, Russia; Voronezh State Technological Academy, Voronezh, Russia.

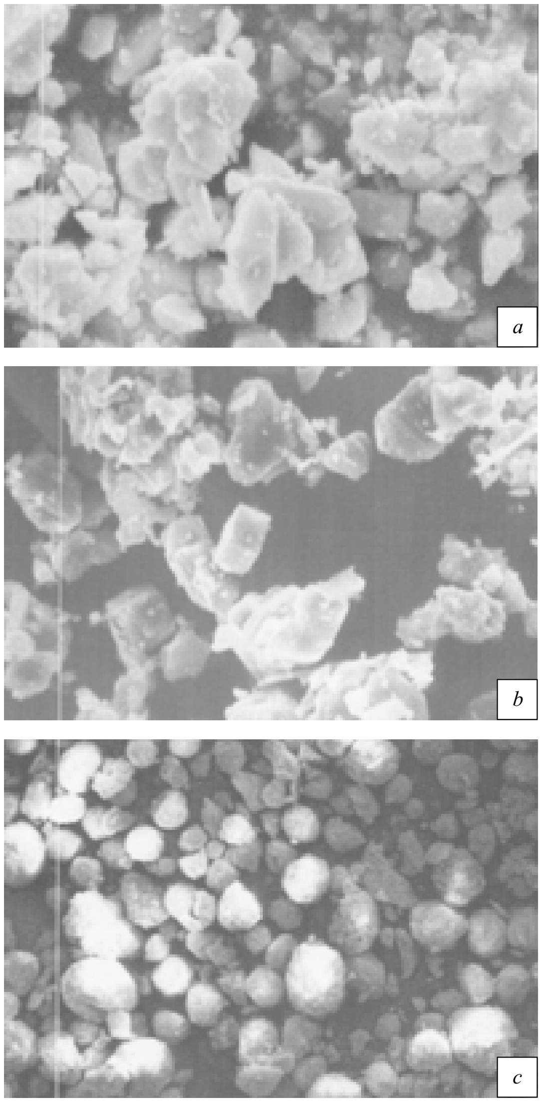

Fig. 1. Electron microscope photos of dust: *a* and *b*) ceramic pigments VK-2 and VK-23, respectively; *c*) molding powder.

it possible to determine the distribution of particles by primary sizes, and a cascade impactor takes into account the aggregation of particles in the gas flows. Using a dot electron microscope, it is possible not only to estimate the level of dust dispersion, but also to determine the qualitative parameters (particle shape, degree of dispersion) [2].

Figure 1 shows the electron microscope photos of dust of some ceramic pigments. The dust particles in their shapes resemble fragments with sharp facets, and large magnification reveals laminar fractures on their surface. Such structure of particles is typical of products of mechanical grinding. The particles are not all monolithic; aggregates are seen as well. The particles of ceramic pigments VK-41, VK-60, and VK-95 have the highest tendency for aggregate formation.

A substantial effect on the operation of a dust-collecting system is produced by the adhesive capacity of the dust, i.e., the capacity of particles for interaction between each other (autohesion) and with a solid surface (adhesion), due to the surface cohesive forces [3, 4]. Adhesive capacity can be manifested in a single layer of particles settling on some surface, for example, on the gas flue walls, filtering surface, electric filter electrodes, etc.)

In the course of dust collection, after suspended particles reach a sedimentation surface, they are fixed to that surface until a subsequent removal of the dust sediment.

The role of adhesive force is displayed only in the initial dust deposition stage, when particles precipitate on a clean surface. At that moment, an adhesive force arises between the solid surface and the single layer of particles directly contacting the surface. After the single layer is formed, the autohesion forces determine the fixing of newly settling particles. The initial stage of dust deposition is significant only for fibrous non-regenerating filters operating under low concentrations of suspended particles. Usually, the initial dust deposition stage in industrial production occurs very rapidly and only on freshly settling surfaces. The single layer becomes firmly fixed to the settling surface and is virtually impossible to remove in the usual mechanical regeneration (in the majority of technological processes this is not required anyway). Therefore, the efficiency of retaining the particles on settling surfaces and their regeneration is mainly determined by the autohesive forces.

Adhesion is manifested in two stages of the filtration process: in trapping particles upon their contact with the filtering element and preventing their entrainment in subsequent gas migration; and in providing for the regeneration of a blocked filter. The adhesive properties of dust frequently determine the expedience of using a particular filter material, regeneration method, and the optimum operation conditions of filters.

The adhesive characteristics of dust can serve as an estimate of the dust behavior inside dust-trapping devices. The autohesive strength of the dust layer P (Pa) serves as the criterion of adhesion. Thus, for group I – $P \le 60$, group II – $60 \le P \le 300$, III – $300 \le P \le 600$, IV – $P > 600$ [I) non-adhesive, II) weakly adhesive, III) medium-adhesive, IV) highly adhesive]. The device developed by E. I. Andrianov [5] is especially convenient for quantitative estimate of the value of P and, accordingly, identifying the adhesion group.

The crystalline structure of particles has a great effect on their adhesive capacity. The dust of ceramic pigments is mainly polycrystalline, i.e. it consists of an enormous number of randomly oriented fine crystals. The particle surface represents a complicated alternation of indents, bulges, projections, and fractures. As a consequence, the surface of each particle has a specific microrelief, which determines the free energy distribution and its averaged parameter referred to unit surface area, i.e., the autohesive strength of the dust layer. The research demonstrated that each type of dust has its shape peculiarities.

The adhesive capacity is related to another dust parameter, namely, friability, estimated based on the natural slant an-

TABLE 1

Ceramic pigment dust	Density, kg/m^3		Dynamic angle, deg	Breaking load (adhesion group), kPa	Wettability, %	Dispersion	
	true	bulk				d_m, μm	log σ
VK-2	4400	1300	42.5	0.36 (III)	72	10	1.35
VK-16	–	–	33.0	0.30 (III)	78	18	3.00
VK-24	4600	–	51.0	0.41 (III)	80	12	1.40
VK-30	–	–	38.0	0.32 (III)	80	–	–
VK-41	4500	2000	37.5	0.28 (II)	74	8	1.30
VK-51	4700	2200	40.2	0.32 (III)	76	6	1.60
VK-60	–	–	31.5	0.27 (II)	74	12	1.35
VK-95	4500	1400	37.0	1.52 (IV)	84	3	0.95
VK-112	4200	1150	45.0	0.34 (III)	82	5	1.20
Pigment batch:							
VK-95	2600	800	–	0.96 (IV)	68	25	1.60
VK-2	2600	600	–	0.90 (IV)	72	6	1.60

gle. This value determines the behavior of dust in the bins of dust-trapping equipment, in which the angle is selected taking into account the friability of collected particles. The natural slant angle was investigated using the Mering – Baranov device.

Wettability is an important service parameter of dust, which has a certain effect on the efficiency of wet dust traps, especially in recirculation. Smooth particles are easier to wet than particles with a rough surface. This is due to the fact that the latter to a greater extent are covered by an absorbed gas shell, which impedes wetting. The wettability of a powdered material is determined through complex reactions of molecules on the interface between the solid, liquid, and gaseous phases leading to the formation of a thin liquid film on the particle surface [6].

The propensity of dust for wetting is estimated by the film flotation method based on determining the weight share of powder particles, which are poured in a thin layer on the surface of water and sink within a certain time period [6].

As the result of experimental studies, [7], it was found that wettability has a negative effect on the operating stability of wet dust collectors, and this negative effect is intensified in the case of using recirculating water. The dust-trapping devices using recirculating water require introduction of wetting solutions when capturing hydrophobic dust. The type and the concentration of these wetting solutions are selected on the basis of additional studies.

In developing and using gas-purification systems, it is necessary to take into account the abrasiveness of the dust, which varies within a wide range. The abrasive effect of dust ought to be taken into account in selecting the dust flow speed, the thickness of metal used in gas flues and gas-purifying plants, and the facing materials for this equipment.

The physiochemical properties of ceramic pigments synthesized according to the energy-saving technology are shown in Table 1.

It is demonstrated in [8] that, other terms being equal, with an increasing size of dust particles, the wear of the metal first increases and then, having reached a maximum, decreases. The maximum wear of metal is caused by dust particles of 90 ± 2 μm size.

REFERENCES

1. *Reference Book on Dust and Ash Collecting* [in Russian], Énergiya, Moscow (1975).
2. V. A. Goremykin, Yu. V. Krasovitskii, B. L. Agapov, et al., "Determination of the degree of dispersion of ceramic pigment dust in dust-gas flow," *Khim. Neft. Mashinostr.*, No. 5 (1999).
3. A. D. Zimon and E. I. Andrianov, *Autohesion of Bulk Materials* [in Russian], Metallurgiya, Moscow (1978).
4. A. D. Zimon, *Adhesion of Dust and Powders* [in Russian], Khimiya, Moscow (1976).
5. E. I. Andrianov, A. D. Zimon, and S. S. Yankovskii, "A device for determining the adhesion of finely dispersed materials," *Zavod. Lab.*, No. 3, 375 – 376 (1972).
6. P. A. Kouzov and L. Ya. Skryabina, *Methods for Determining the Physiochemical Properties of Industrial Dust* [in Russian], Khimiya, Leningrad (1983).
7. V. A. Goremykin, Yu. V. Krasovitskii, V. Ya. Lygina, et al., in: *Engineering and Technology of Environmentally Clean Production. Proceedings of II Int. Symposium of Young Scientists, Postgraduates, and Students* [in Russian], Moscow (1998), pp. 27 – 28.
8. P. V. Baltrenas, *Dust Removal from Air at Production Facilities for Building Materials* [in Russian], Stroiizdat, Moscow (1990).